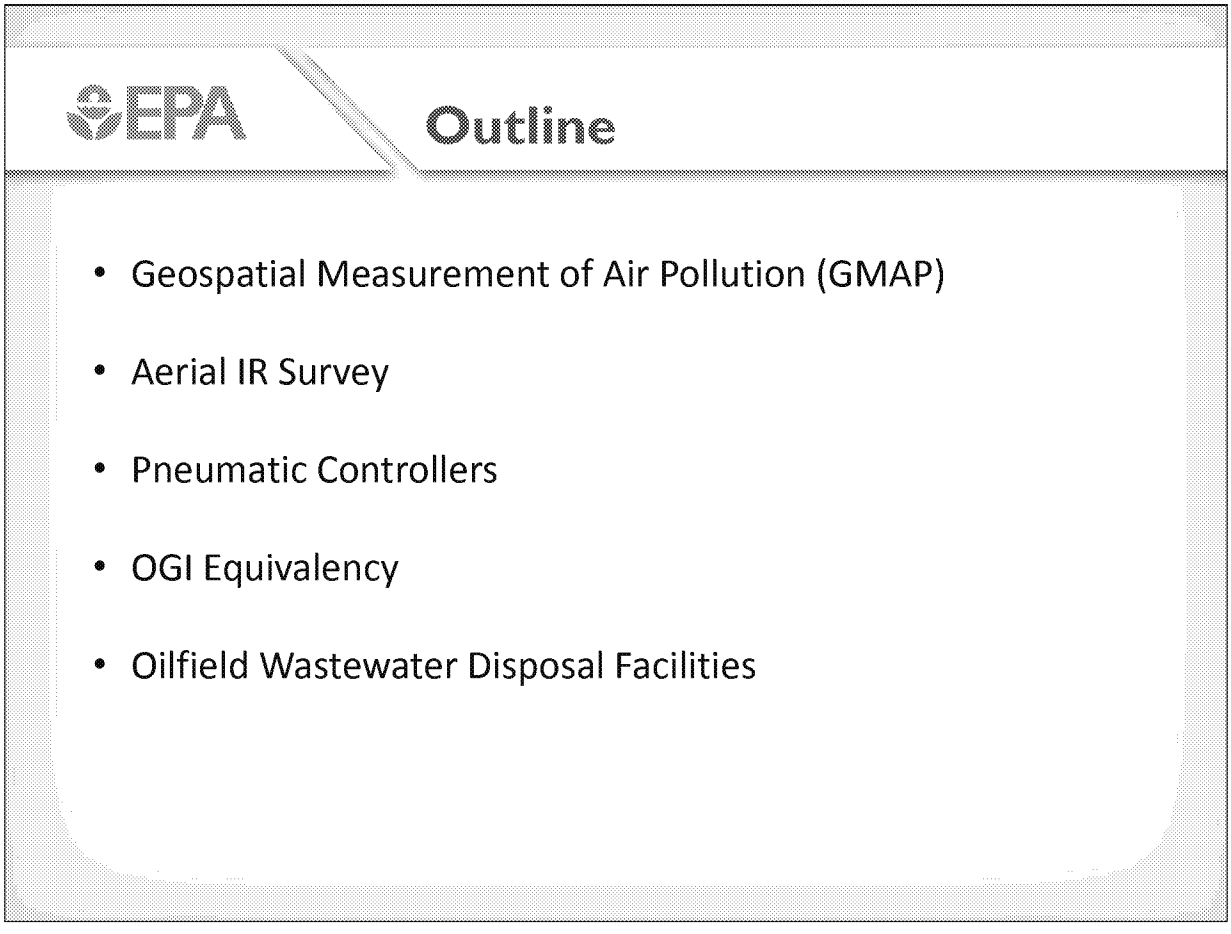
R8 Efforts to Improve Understanding of Oil & Gas Emissions

EPA Region 8 State Air Directors Meeting

8/22/2018



Scrappy funding - RARE, working with federal/state partners to leverage existing contracts, utilize staff time and EPA equipment with strong relationships with ORD and NEIC

In an effort for quick turnaround (so it may be incomplete), here is a list of R8 O&G research/science projects, that can get us thinking ...

Combustor combustion efficiency testing with hyper-spectral remote imaging (Rebecca Matichuk, Gail Tonnesen, Adam Eisele)
Evaluation of CMAQ for simulating winter ozone in the Uinta Basin (Matichuk, Tonnesen, ORD)
UDAQ/Ute Tribe/BLM/R8 Uinta Basin Pneumatic Controller study (Mike Stovern, Beeler and ORD RARE)
CDPHE/R8 Pneumatic Controller Study in the DJ Basin (Stovern, Colin Schwartz, Beeler and ORD Technical advice)
Augmented Hi-Flow Volume Sampler (Stovern, Beeler, ORD RARE)
Passive tube air sampling around wellpads in the DJ (Eisele, ORD)
BLM/UDAQ/Ute Tribe/USU/R8 Aerial IR Survey of the Uinta Basin (Beeler)
CDPHE/COGCC/NEIC/R8 Geospatial Measurement of Air Pollution (GMAP) surveys in the DJ Basin
R8/ORD/OAQPS/CSU – Testing of OGI operators at CSU/DOE's METEC test facility (Beeler)
Produced water speciation on Wind River (Treasure Bailley, Tricia Pfeiffer, ORD RARE)
CDPHE/Ute Mountain Ute Tribe/NEIC/R8 Assessing road spreading of produced water in SW Colorado (Bailley, Cindy Schaffer)
...

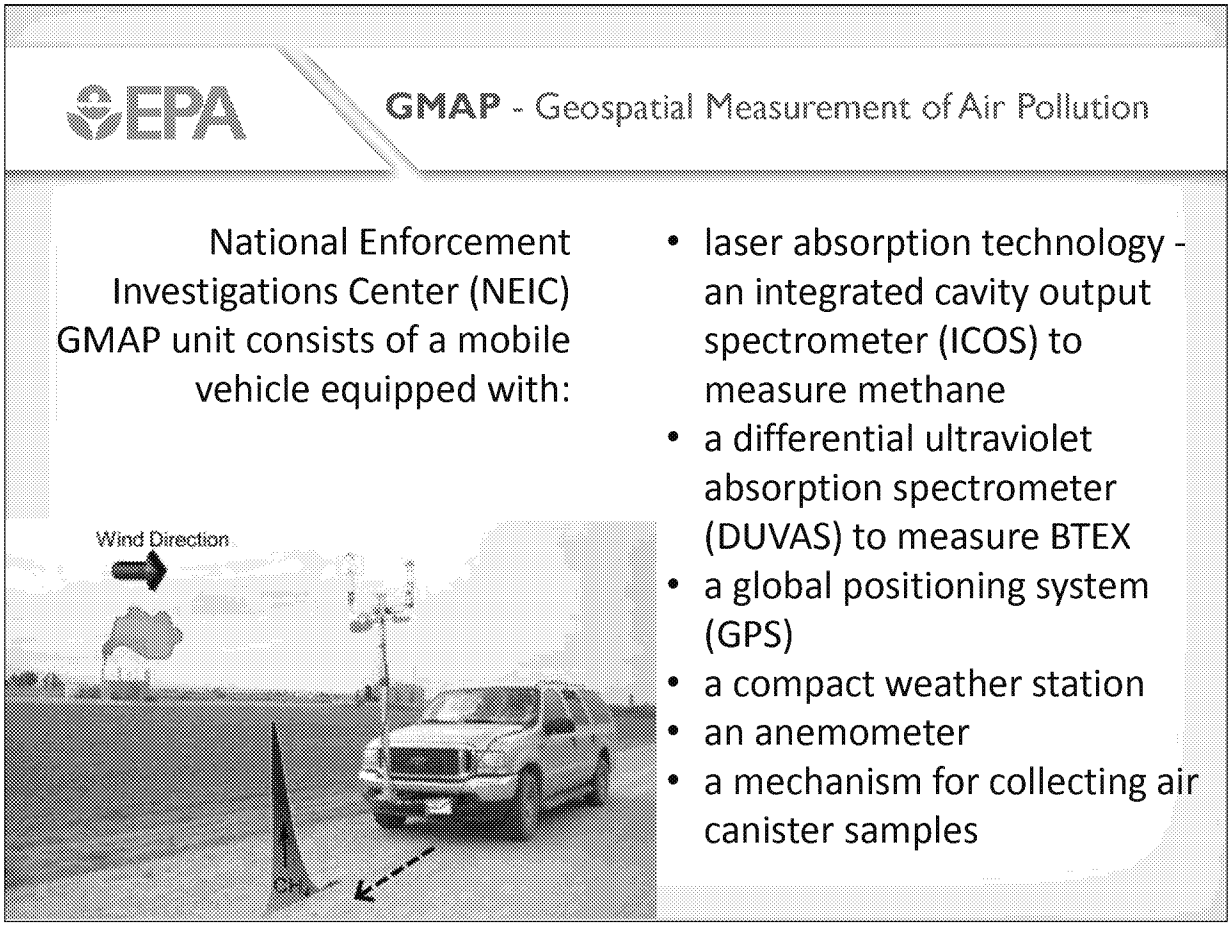


Photo from: Brantley, H. L., Thoma, E. D., Squier, W. C., Guven, B. B., & Lyon, D. (2014). Assessment of methane emissions from oil and gas production pads using mobile measurements. Environmental science & technology, 48(24), 14508-14515.

GMAP December 18 2017.pptx

From NEIC's "Region 8 Next Generation Monitoring 2016 – Denver-Julesburg Basin, Colorado" Final Report, "Final Report SP0368.pdf"
[See email: From: Squier, Bill Sent: Tuesday, October 24, 2017 9:01 AM To: Beeler, Cindy <Beeler.Cindy@epa.gov> Subject: Squier, Bill shared the folder "R8 GMAP 2016" with you NEIC GMAP for CDPHE]

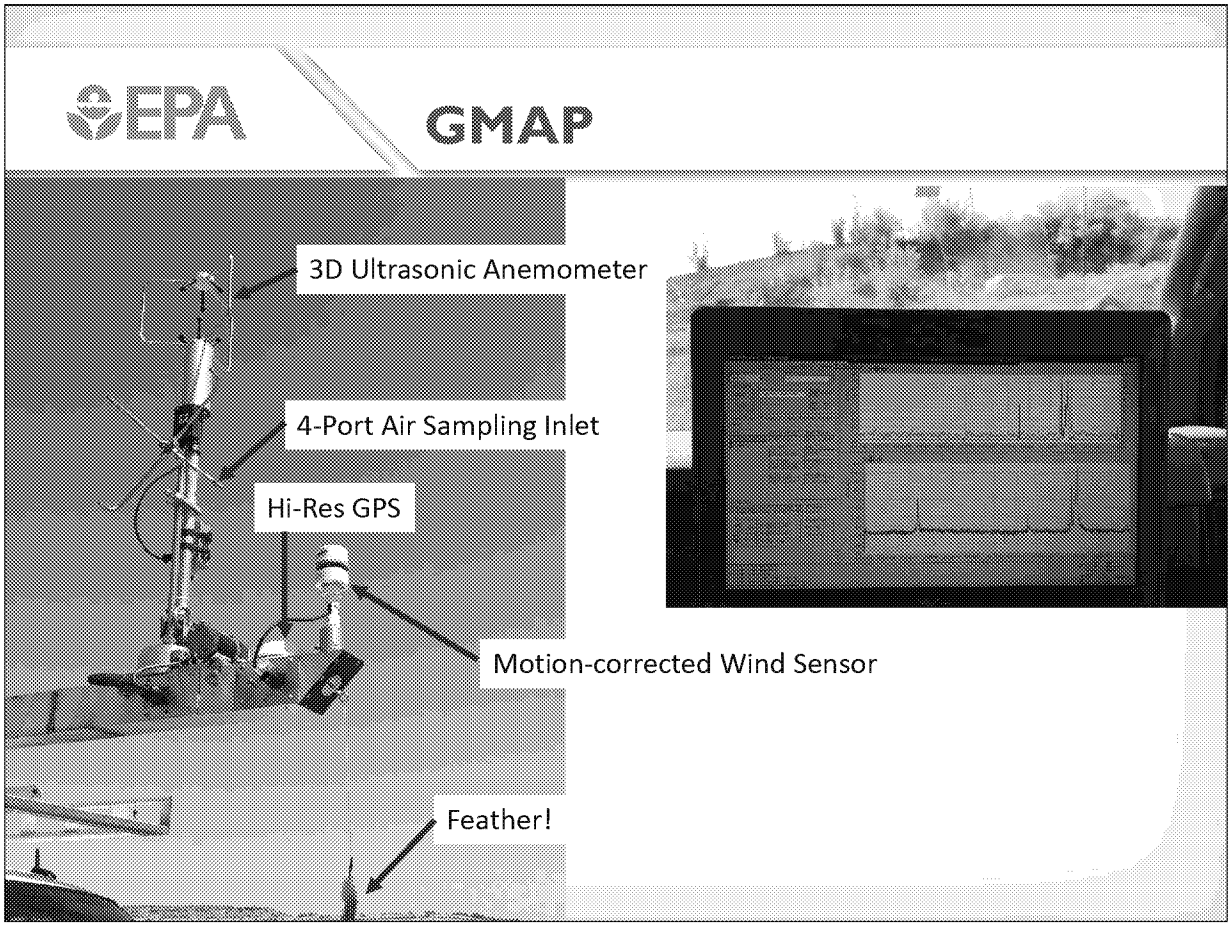
Data collected from the GMAP unit are intended to be used only for screening and targeting purposes. During NEIC's development of this GMAP
technology, data are not intended to be used quantitatively.

Concentration readings for each analyte (methane, benzene, ethylbenzene, toluene, m-xylene, o-xylene, and p-xylene) are generated approximately every second. Methane concentrations are reported in the parts per million volume (ppm) range, and BTEX concentrations are reported in the parts per billion volume (ppb) range.

The reported concentrations summarized in Table 3 are based on the analytical data obtained approximately every second from the GMAP monitoring instruments. The concentrations depicted on GMAP survey maps in Appendix A represent the average measured concentration per 2.5-meter distance
traveled by the GMAP vehicle. Generally, the average chemical concentrations available from the GMAP survey maps are lower than those measured by the GMAP monitoring instruments each second. The concentrations shown in Table 3 are not intended to be quantitative values but rather to be used to identify potential emission sources.

EPA

GMAP


3D Ultrasonic Anemometer
4-Port Air Sampling Inlet
Hi-Res GPS
Motion-corrected Wind Sensor
Feather!

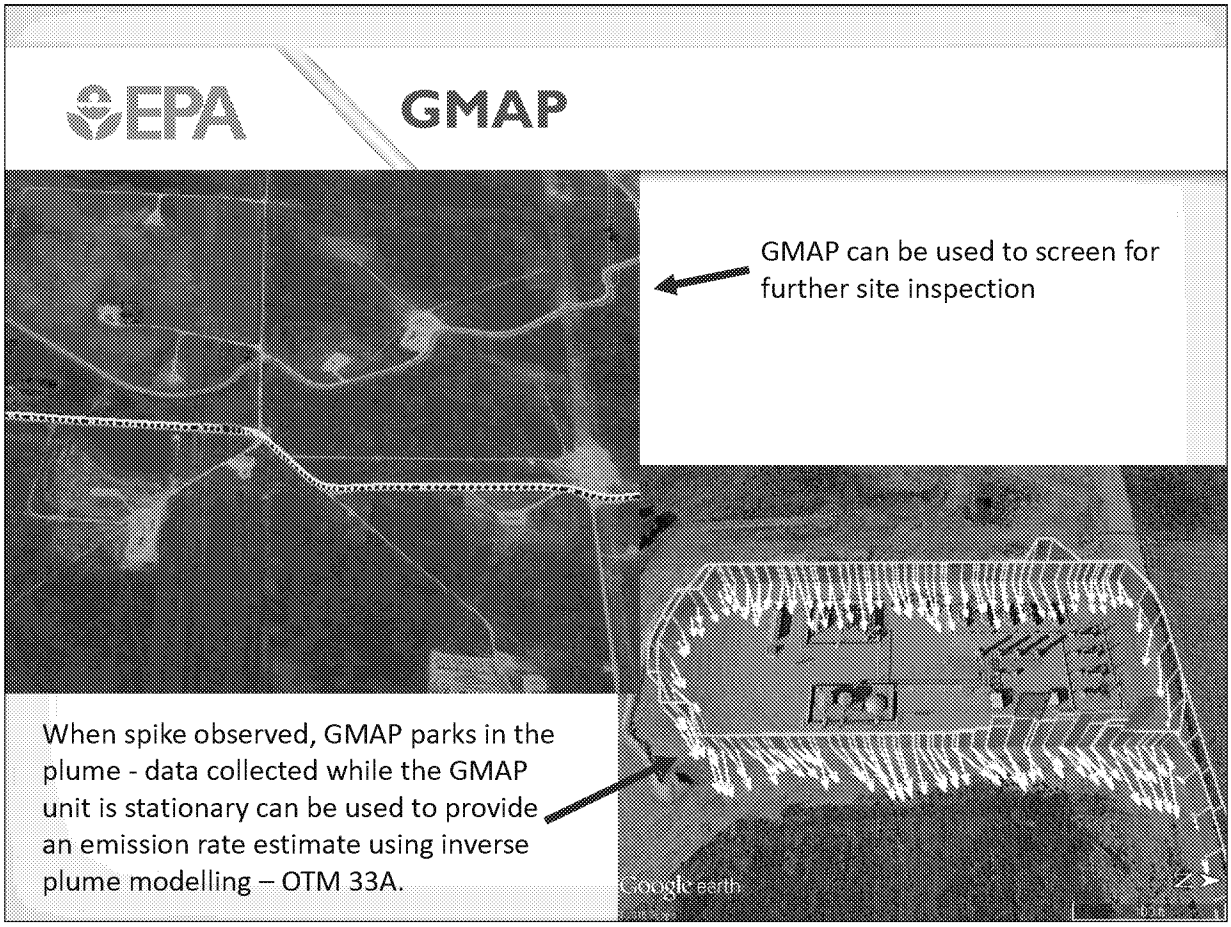


Photo on left: 072716_08-SUMColl1_CH4.kml

Photo on right: GMAP December 18 2017.pptx

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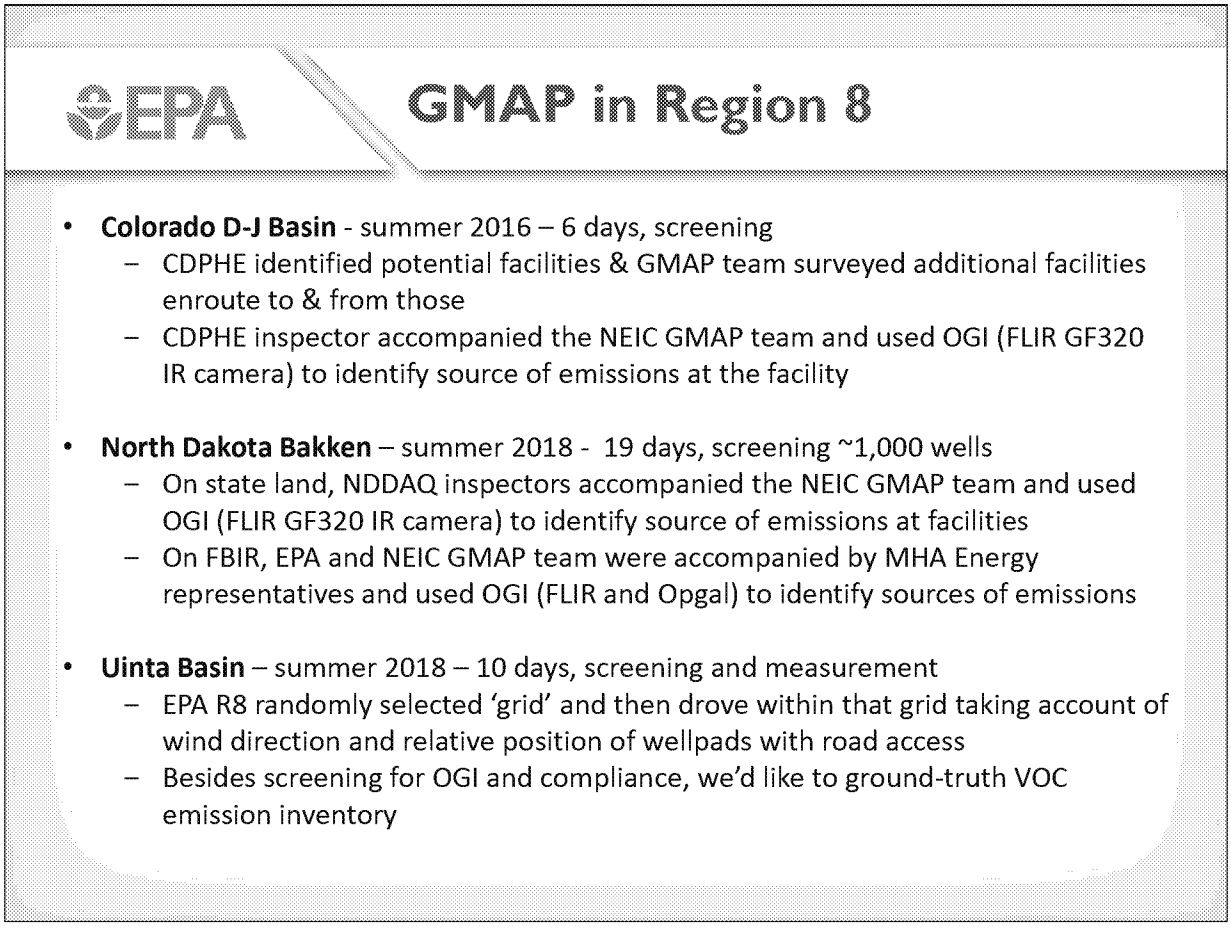
technology, data are not intended to be used quantitatively .

In order to easily evaluate significant quantities of data generated by the GMAP unit, specific chemical concentration values are visually displayed on Google Earth map plots. Concentration readings for each analyte are generated approximately every second, and these data are recorded along with the corresponding GPS and meteorological data. The concentration data are then converted into color bar graphs which are overlaid on Google Earth map plots. For each individual mapping run, the concentration data are automatically converted into the colored bar graphs , where the highest concentrations are displayed in red and the lowest concentrations are displayed in green . Generally, colors shown on mapping run bar graphs are relative only to the data set in the specific mapping run, with green representing lower relative concentrations and red representing higher relative concentrations

****

OTM-33a
Different researchers have used this methodology o measure total wellpad emissions:
Brantley, H. L., Thoma, E. D., Squier, W. C., Guven, B. B., & Lyon, D. (2014). Assessment of methane emissions from oil and gas production pads using mobile measurements. Environmental science & technology, 48(24), 14508-14515.

Robertson, A. M., Edie, R., Snare, D., Soltis, J., Field, R. A., Burkhart, M. D., ... & Murphy, S. M. (2017). Variation in Methane Emission Rates from Well Pads in Four Oil and Gas Basins with Contrasting Production Volumes and Compositions. Environmental Science & Technology.
Bell, C. S., Vaughn, T. L., Zimmerle, D., Herndon, S. C., Yacovitch, T. I., Heath, G. A., ... & Robertson, A. M. (2017). Comparison of methane emission estimates from multiple measurement techniques at natural gas production pads. Elementa, 5(NREL/JA-6A20-70835).



NO funding necessary – staff time and EPA equipment

CDPHE staff – Tim Taylor and Becky Wilson

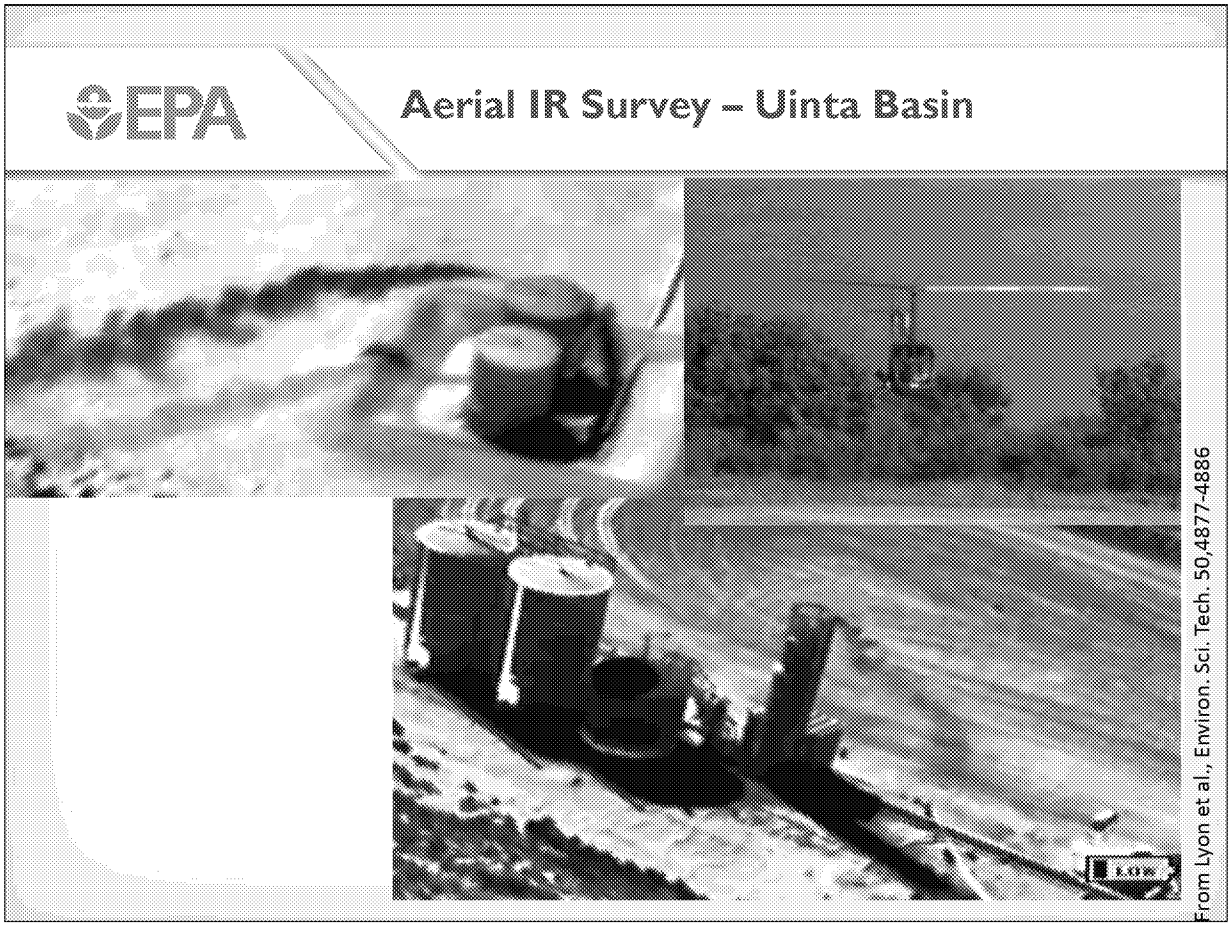
NDDH is "going" to be the North Dakota Division of Air Quality (DoAQ) any minute so lets start using it.

The following all got out and rode shotgun with Bill Squire!
Adam Rookey
Russell Martin
Jaden Voth
Adam Miller
Jim Semerad

From: North, Alexis Sent: Monday, August 13, 2018 10:45 AM To: Beeler, Cindy <Beeler.Cindy@epa.gov> Subject: RE: GMAP - ND

North Dakota Bakken - summer 2018 – 19 days, screening
NDDH, EPA and MHA Energy screened nearly 1,000 well sites total over 19 days (16 days on state land, 3 days on FBIR)
On state land, NDDH inspectors accompanied the NEIC GMAP team and used OGI (FLIR GF320 IR camera) to identify source of emissions at facilities.
On FBIR, EPA and NEIC GMAP team were accompanied by MHE Energy representatives and used OGI (FLIR and Opgal) to identify source of emissions at facilities.

Alexis North, Environmental Scientist

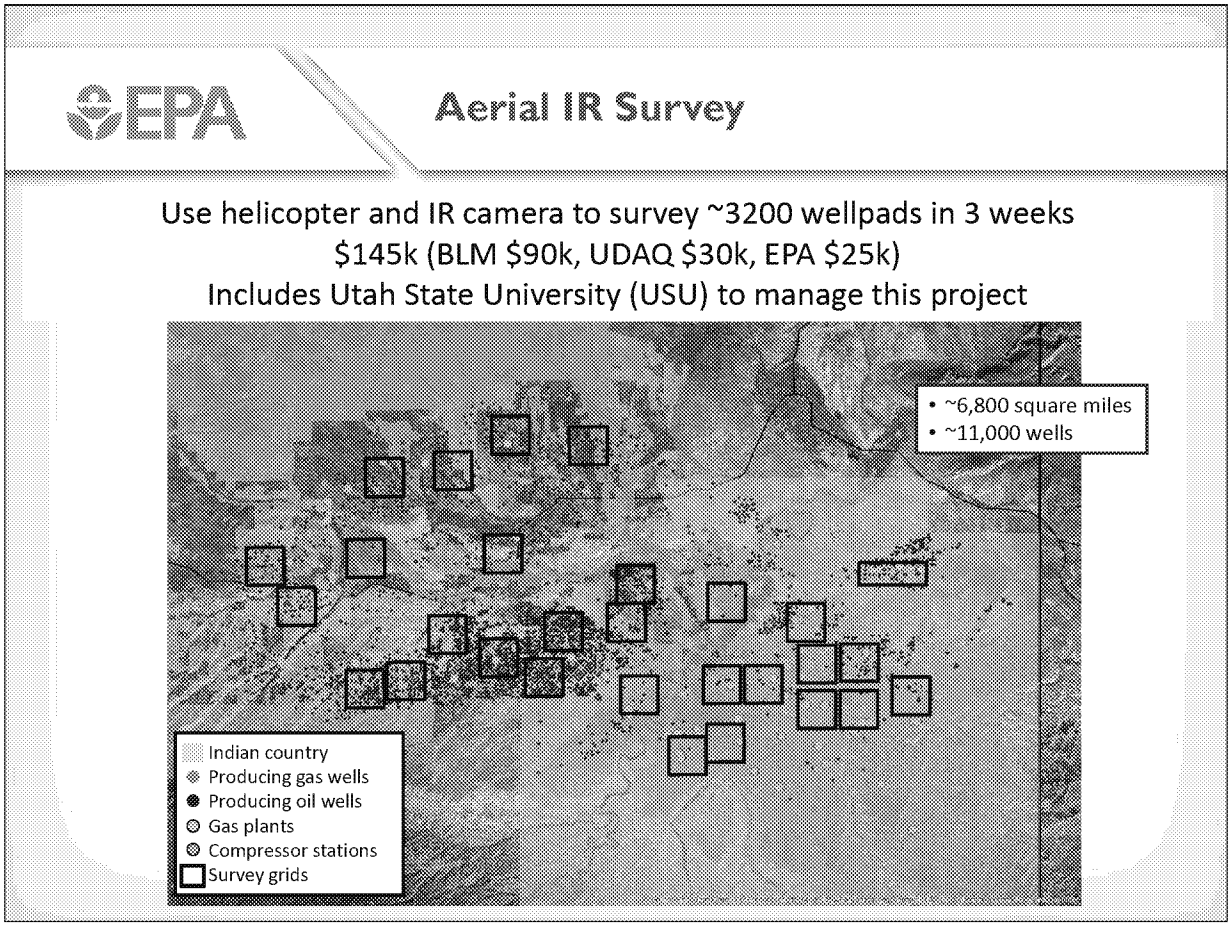


Highlight "potential" of this project – not certain yet.

From: Hoffman, Kent [mailto:khoffman@blm.gov] Sent: Monday, July 11, 2016 12:07 PM To: Beeler, Cindy <Beeler.Cindy@epa.gov> Cc: Leonard Herr <lherr@blm.gov> Subject: Re: Aerial IR Survey - question

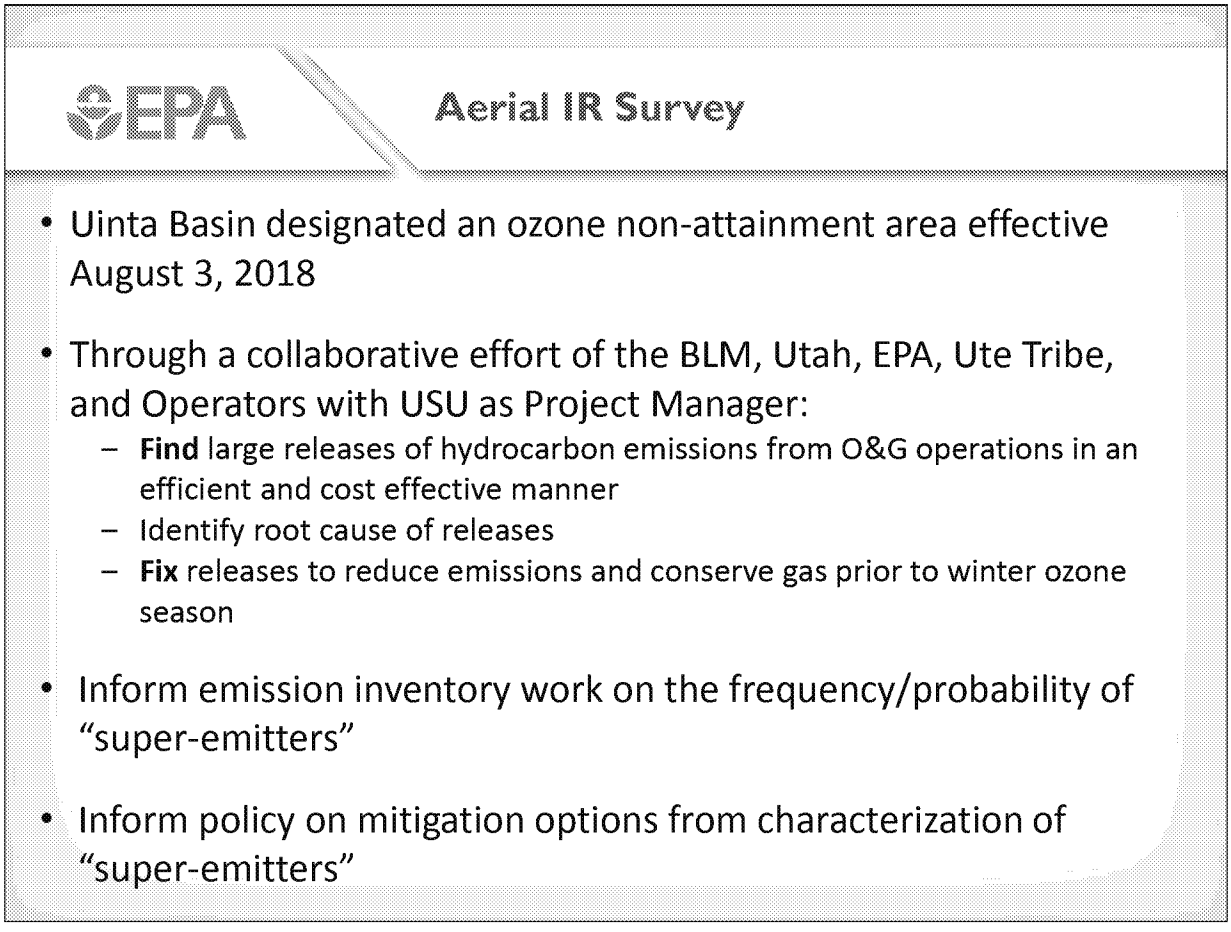
Yes. We are supportive of the project and anytime we can inform folks as to the scope and intent, that is worthwhile. As you know, we are still in the preliminary phase of geeting this project off the ground (little pun there) so we need to caveat that it is somewhere between conceptual and confirmed....

take care,
kent



Set up grids – 1.5 hours flying time within grid. Total available flying time ~2.5 hours so set up grids within half hour flying time of two airports.

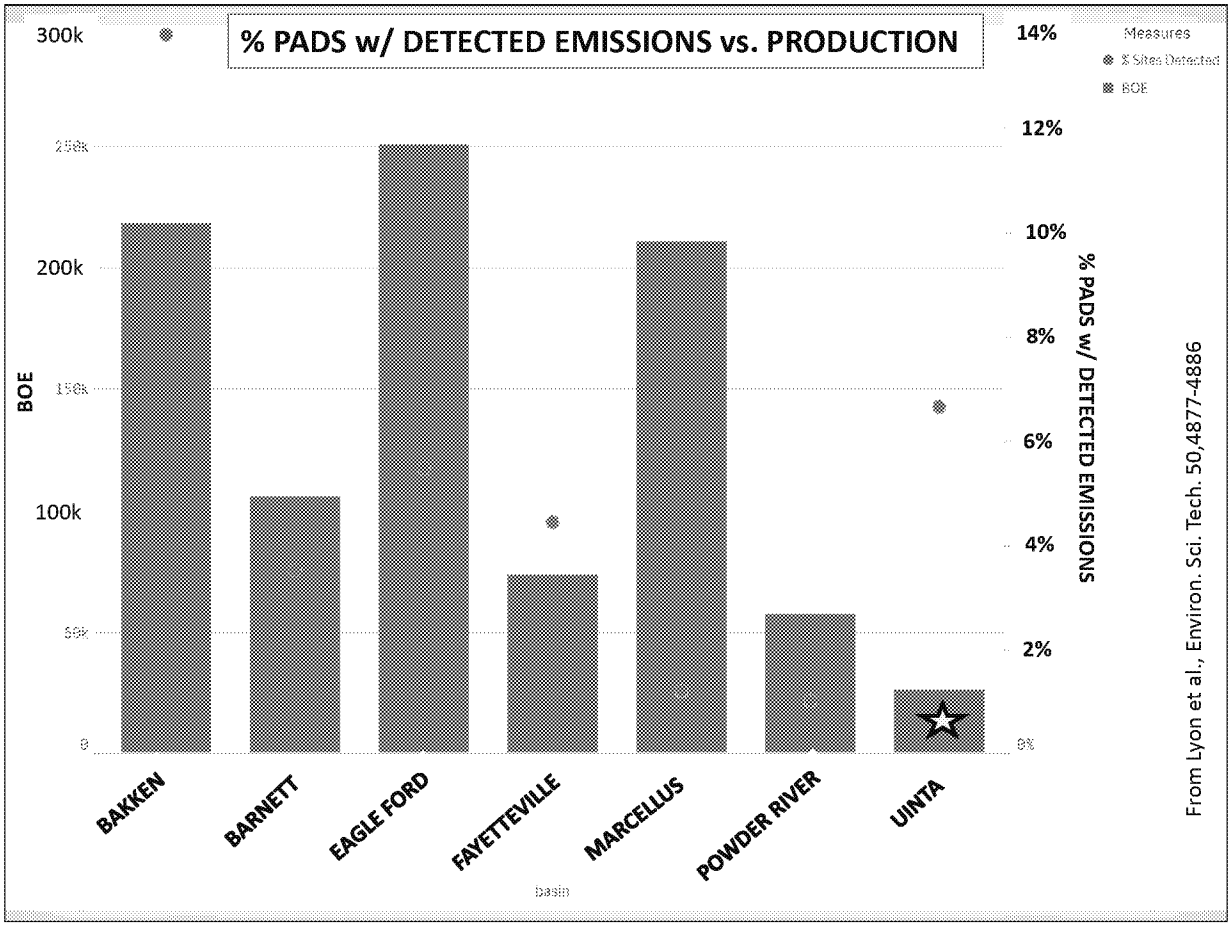
Ensure grids representative of Basin by: operator, oil vs. gas, age, production volumes



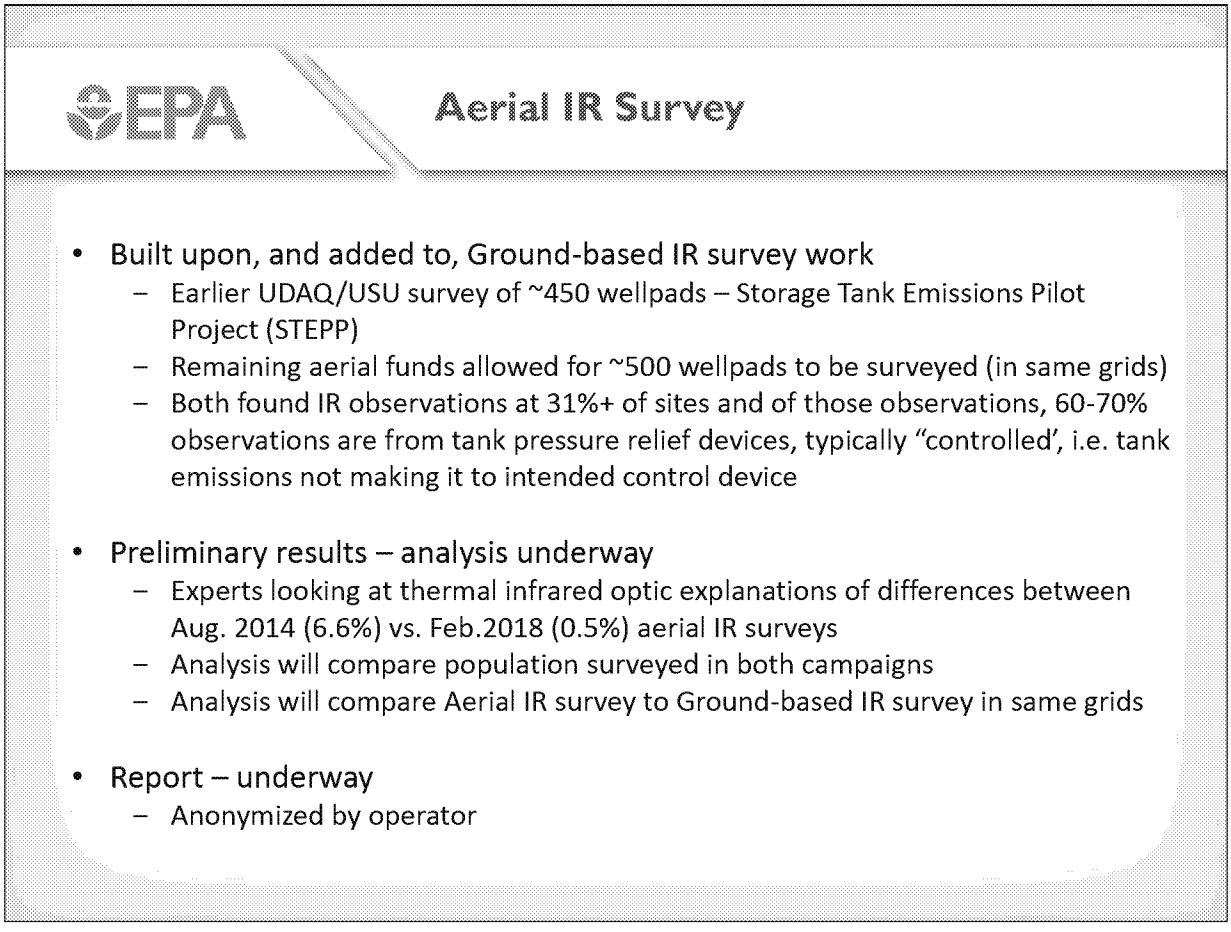
Provide survey information to operators, allow them to inspect facilities, repair leaks, and report information about repairs.

NEPA – how Aerial IR survey fits in:
Component of the BLM's Basin-wide Ozone Action Plan outlined in previous NEPA documents
Component of the "enhanced mitigation" required in Adaptive Management Strategy triggered by ozone exceedances in 5 already-approved EISs/EAs
As a component of ozone mitigation in the new NEPA actions under review
Operators reduce emissions from existing sources through a "Find & Fix" approach and share lessons learned on root causes of super-emitters
Inform emission inventory work on the frequency/probability of super-emitters
Inform policy on mitigation options from characterization of super-emitters - root causes and how to prevent through maintenance practices

Benefits to NEPA Project Proponent Operators:
Discrete, cost-effective project
Detection costs borne by regulators
Supports ROD commitments to enhanced mitigation and supports need to avoid adverse ozone impacts in NEPA projects currently awaiting approval to show reductions in existing emissions
"Find & Fix" versus enforcement (fix before winter ozone season)
Inform emission inventory work for more complete emission inventory which will inform cost-effective emission mitigation options for SIP
Learn about root causes of super-emitters to prevent in future through maintenance practices
Conserve gas → more to market



EDF Uinta Basin flyover in August 2014 … BLM/UDAQ/EPA/Ute Tribe Flyover late Feb/early March 2018
"apparent ground temp" and ambient air temp differences
Oil wells more emissions than gas wells (bigger proportion of EDF wells were oil)
More observations at New wells vs. old wells (EDF had bigger proportion of new wells in 2014 than we did in 2018)



Work done subsequent to the STEPP report below, in conjunction with the UB Aerial IR Survey, was additional ground-based IR surveys at 517 wellpads had IR-observations at 31% of the sites. These surveys were on Indian country and State land and we've not received a draft report to understand emission sources observed but they used a similar grading of IR observations as STEPP and 38% were 'small', 39% 'medium' and 22% 'large' (and 2% 'unnoted').

Storage Tank Emissions Pilot Project (STEPP) 7/17/17 ... https://documents.deq.utah.gov/air-quality/planning/technical-analysis/DAQ-2017-009061.pdf

Between 8/2/16-10/31/16, USU visited 454 natural gas and oil well pads in Duchesne and Uintah Counties, and used an infrared imaging camera to detect emissions of hydrocarbon gases to the atmosphere from liquid storage tanks on the well pads on State land. Even though these tanks were equipped with emissions controls, we were able to detect one or more infrared-visible emission plumes at 39% of the well pads. Most of the tank plumes we observed were emitted before they reached the control device. Therefore, the problem is not so much a failure of the control devices themselves but a failure to adequately deliver escaping gases to the control devices.

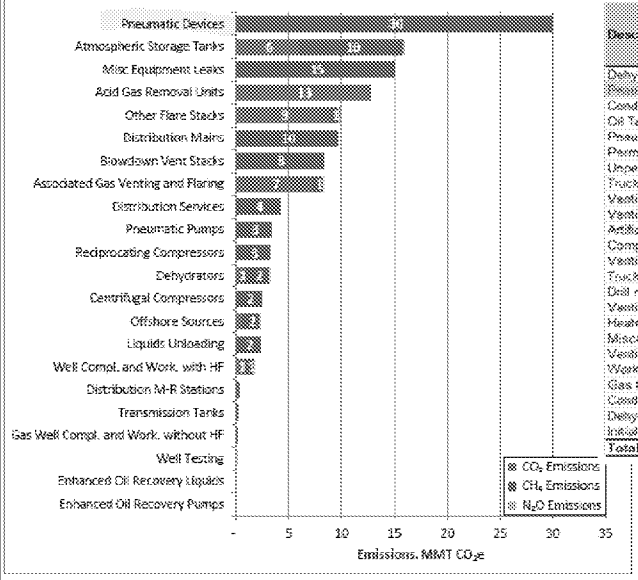
The STEPP study was a fact-finding endeavor, not intended to regulate emissions by the industry. There was never an intention to issue citations or assess penalties if emissions were found. Therefore, the locations and the owners of emitting tanks will not become part of the public record, and this report contains only de-identified statistical data. Company-specific results were shared with the companies themselves, but not among the companies nor with the public. Companies were also given the opportunity to review this document prior to its release.

454 well pads with controlled tanks were visited, and any detectable emissions were recorded. A total of 196 plumes, or 0.43 plumes per pad, were observed.
Emissions were detectable at 178 (39%) of the well pads. Tables 2 and 3 summarize the results. Each well pad is assigned to one of four classes, N (no detectable emissions), S (small), M (medium), and L (large), defined as the size of the largest plume observed at the pad.
Together, thief hatches and pressure relief valves account for 74% of all observed plumes.

Follow-up discussions were solicited and encouraged, during which time tank owner/operators were able to respond to the study, offer clarifications, and describe any corrective action taken. Some, but not all, of the companies engaged in follow-up discussions. These discussions occurred in January and February 2017. Video footage and the camera operator logs and Excel notebooks were shared with the owner/operators of the well pads. They were then invited to meet with personnel from TriCounty Health, UDAQ, and USU, to discuss any concerns about the project and report any repairs made to their tanks. Some, but not all, of the six owners met with us in January or February 2017. In all, we heard back on 48 of the 178 well pads at which we had observed emissions. In a large majority of cases, the owners agreed that the tanks in question had been emitting. Of these 48, repairs had been performed or scheduled on 44, while owners reported they had found no emissions at two of the pads. Two other pads had been misidentified and did not have controlled tanks. Many of the 48 well pads had passed a recent AVO inspection, indicating, as expected, that AVO inspections are not as sensitive as infrared imaging.

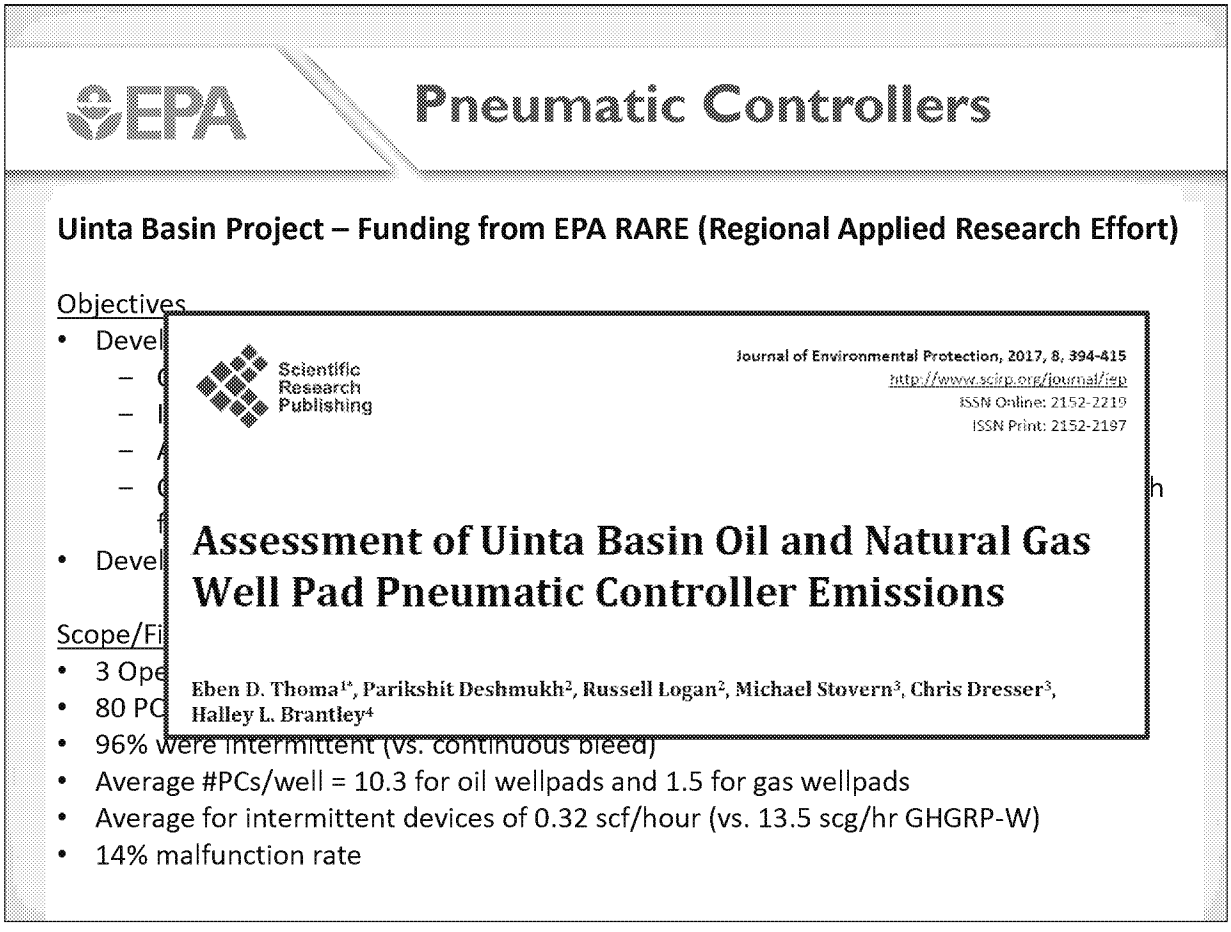
Pneumatic Controllers

Figure 4: 2016 Reported Process Emission Sources



WRAP Phase III Emission Inventory – Uinta Basin

Description	2012 Emissions				
	NOx (tons/year)	VOC (tons/year)	CO (tons/year)	SOx (tons/year)	PM10 (tons/year)
Dehydrator	225	32,666	189	0	17
Pneumatic devices	0	26,083	0	0	0
Condensate tank	0	21,719	0	0	0
Oil Tank	0	20,782	0	0	0
Pneumatic pumps	0	14,332	0	0	0
Permitted Sources	3,184	4,359	2,647	8	48
Unpermitted Fugitives	0	3,212	0	0	0
Truck Loading of Oil	0	1,391	0	0	0
Venting - Compressor Startup	0	1,300	0	0	0
Venting - Compressor Shutdown	0	1,233	0	0	0
Artificial Lift	3,053	956	34,756	2	136
Compressor engines	3,169	895	4,236	0	46
Venting - blowdowns	0	469	0	0	0
Truck Loading of Condensate	0	445	0	0	0
Drill rigs	4,773	362	1,667	3	236
Venting - initial completions	0	332	0	0	0
Heaters	1,671	96	1,426	11	132
Miscellaneous engines	199	63	281	0	1
Venting - recompletions	0	51	0	0	0
Workover rigs	371	22	81	0	16
Gas Plant Truck Loading	0	12	0	0	0
Condensate tank flaring	2	8	2	0	0
Dehydrator Flaring	0	6	1	0	0
Initial completion Flaring	1	0	4	0	0
Total	16,547	127,495	44,925	24	631



Appendix – RARE Grant Study Limitations for UB-wide Applicability

From the study measurements in the Uinta Basin of a limited number of pneumatic controllers, Region 8 agrees with UDAQ that the average whole gas emission factor for intermittent pneumatic devices is likely to be less than the Greenhouse Gas Reporting Rule, subpart W, Western U.S. intermittent bleed pneumatic device whole gas emission factor of 13.5 scf/hour. However, we would argue that the Uinta Basin emission measurement study estimating an overall average for intermittent devices of 0.32 scf/hour, is too low a number to apply for all intermittent devices in the Basin for the following reasons:

The sample size was relatively small compared to the universe in the Uinta Basin
Sample size of 18 wells at 8 wellpads out of a universe of ~12,000 wells at ~8,500 wellpads
80 pneumatic controllers measured (77 intermittent) out of a universe of ~44,700 (~35,700 intermittent)

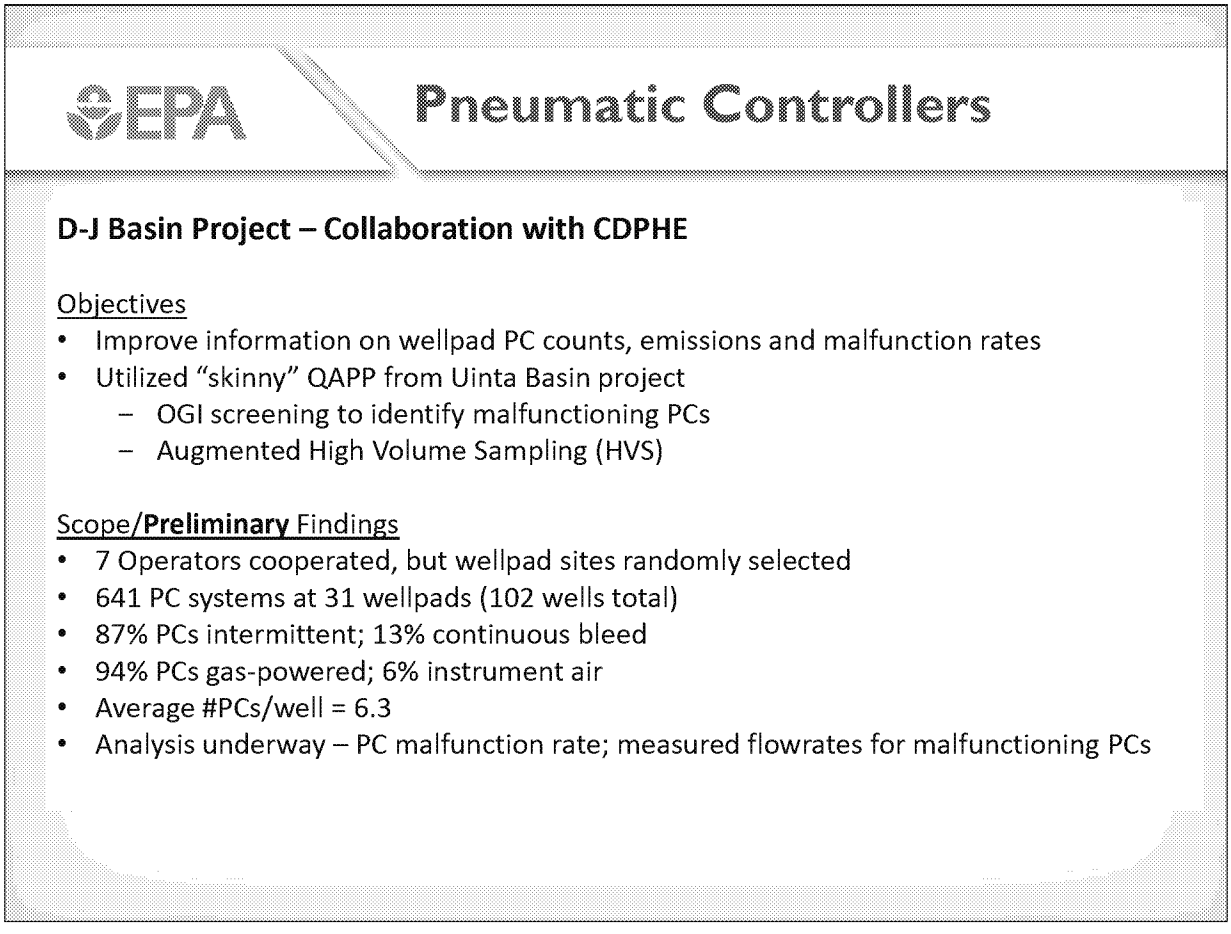
The population of pneumatic controllers observed and measured could not be characterized as representative nor random
Three operators cooperated on the study and selected the sites at which the measurement team could access (not random selection)
Most sites selected were considered to be relatively well-maintained and subject to regular company inspections. One of the 8 wellpads (Gas Site 3) was intentionally chosen to be an older site, without the benefit of recent company inspection and the malfunction frequency at this site was 60% (compared to an overall study average of 14.3%)
The flow rate of malfunctioning controllers could be significantly higher as reported by other studies like Dave Allen's pneumatic controller research where of 377 PCs measured in several basins, 20% of the devices accounted for 96% of the emissions

There appears to be a difference in which pneumatic controllers were counted in the study compared to the number reported in the 2014 UBEI
For the five oil sites in the study, an average of 10.3 PC systems/well were counted and used in estimating an overall average gas flow rate and the malfunction rate, while the two oil operators who cooperated in the study provided what averages to be 5.2 PCs/well for their combined population of 1,909 wellpads in the 2014 UBEI

Some important categories of pneumatic controllers that may be higher emitting (associated with compressor, dehydrators, liquids unloading, etc.) where not part of the study

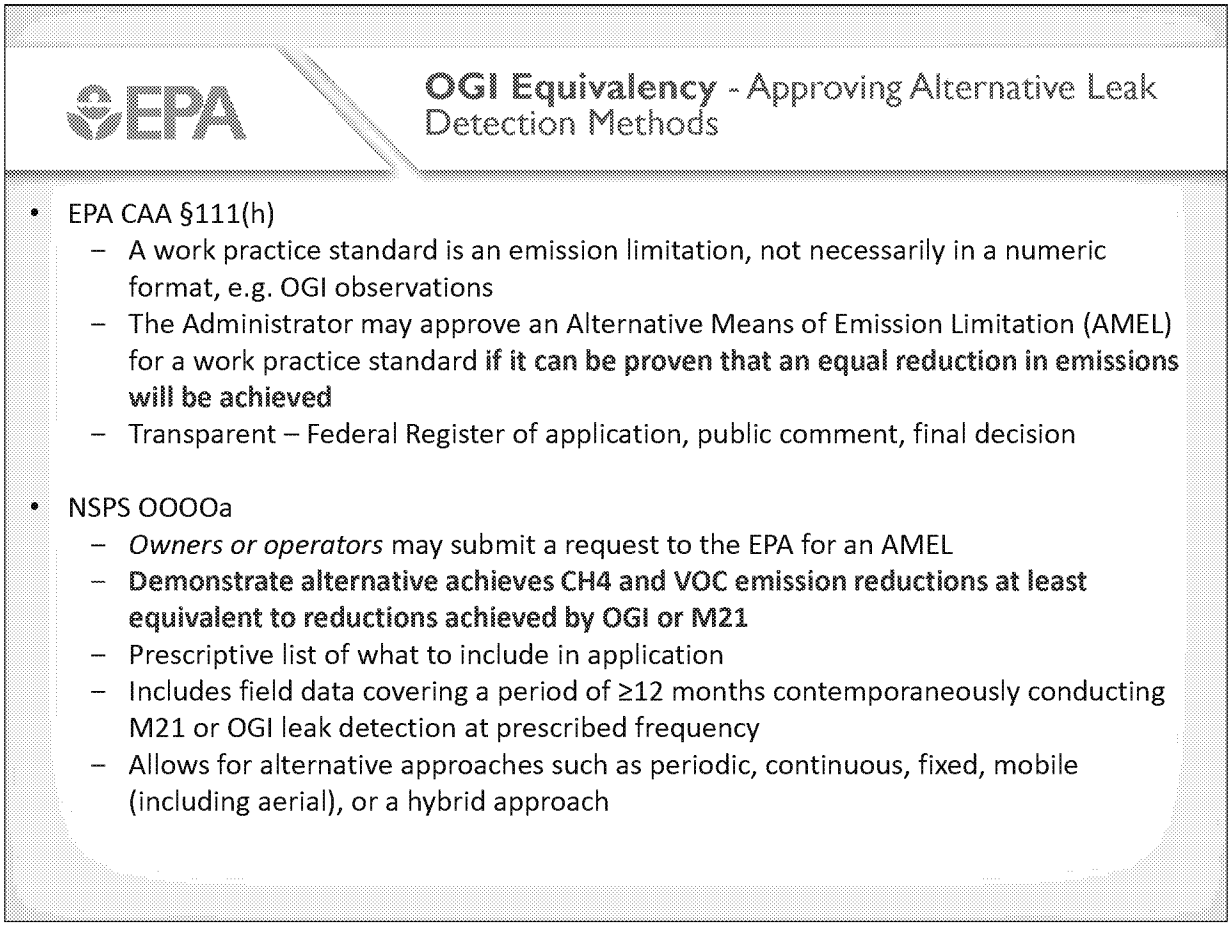
The Uinta Basin PC Study did achieve many of the objectives it set out to achieve on a limited EPA budget and scope and a limited number of operators participating:
We improved our understanding of pneumatic controllers at the facilities visited – activity factors, function, type, make/model, service, actuation counts
We acquired emission measurement data from PCs for the first time in the Uinta Basin
We improved emission measurement methods to support method development – protocol to identify malfunctioning PCs; PC supply and exhaust gas measurements; and an augmented High Volume Sampling measurement method for continuous emissions
We learned how to differentiate PC emissions versus fugitive or malfunction emissions by defining a pneumatic controller system

Allen, D., et al. (2014), Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Pneumatic Controllers. Environmental Science & Technology.



Supports CDPHE work with taskforce looking at PCs – state, operators, EDF

CO PC Project in this list as it came about with a request from Mark McMillan following our Uinta Basin PC Project, both examples of better understanding oil & gas emissions. It is a good example of cooperative federalism, securing ORD technical assistance with no extra funding, and creating a learning opportunity for staff from both agencies.



Methane and VOC leak detection technology is undergoing continuous and rapid development and innovation, potentially yielding, for example, continuous emissions monitoring technologies.

To facilitate the application and review process, information to be provided in the application that would be needed for EPA to expeditiously evaluate the emerging technology must include:
a description of the emerging technology and the associated monitoring instrument or measurement technology;
a description of the method and data quality used to ensure the effectiveness of the technology;
a description of the method detection limit of the technology and the action level at which fugitive emissions would be detected;
a description of the quality assurance and control measures employed by the technology;
field data (covering a period of at least 12 months and contemporaneously conducting M21 or OGI leak detection at prescribed frequency) that verify the feasibility and detection capabilities of the technology; and
any restrictions for using the technology.

Consistent with section 111(h)(3) of the CAA, any application will be publicly noticed in the Federal Register, which the EPA intends to provide within six months after receiving a complete application, including all required information for evaluation. The EPA will provide an opportunity for public hearing and comment on the application and on intended action the EPA might take. The EPA intends to make a final determination within six months after the close of the public comment period. The EPA will also publish its final determination in the Federal Register. If final determination is a denial, the EPA will provide reasoning for denial and recommendations for further development and evaluation of the emerging technology, if appropriate.

States and others have their own approaches to approval of alternative leak detection technologies for use in O&G:
CO
AIMM (Approved Instrument Monitoring Method)
BLM
Alternative Monitoring Device made at national level
Alternative Instrument-based Leak Detection program made by Operator via Sundry Notice and State Office Director approval – operator and field specific

A state that wants to allow AMELs in a SIP could:
Submit the specific AMEL in a SIP revision;
Create a SIP provision to the effect that any AMEL approved by the Administrator under OOOOa would also be approved for that owner/operator for SIP purposes; or
Create a SIP process that is sufficiently bounded so that EPA could know in advance that the State's approval of an AMEL would be, in EPA's judgment, equivalent

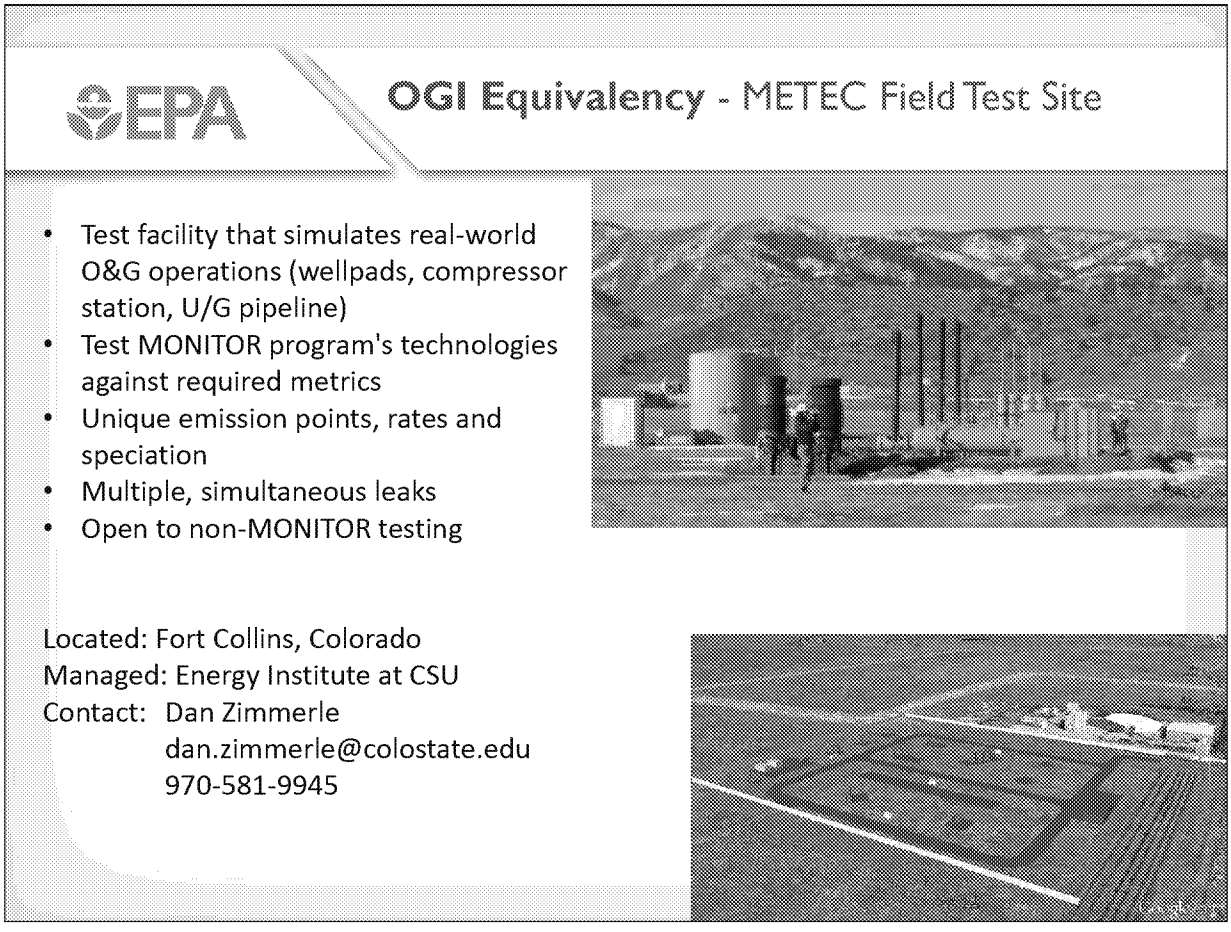
OGI Equivalency

EPA R8/ORD/OAQPS and CSU/METEC - **EPA Study on OGI Baseline Efficacy**

- EPA developed a robust QAPP for this research
- OGI operators follow their own protocol and use their own camera equipment to include hardware and protocol differences in the testing
- METEC provides the emissions, locations and rates
- To-date completed 9 days of testing with 19 OGI operators:
  - 4 O&G operators with 6 LDAR teams
  - 10 regulatory teams (CDPHE, COGCC, WDEQ, EPA R8, EPA NEIC, Boulder County),
  - 1 commercial detection team
  - 1 academic team
  - 1 OGI manufacturer team
- Funding for another 3 weeks of OGI Operators testing (thru mid-September)
  - Includes team from Alberta Energy Regulators

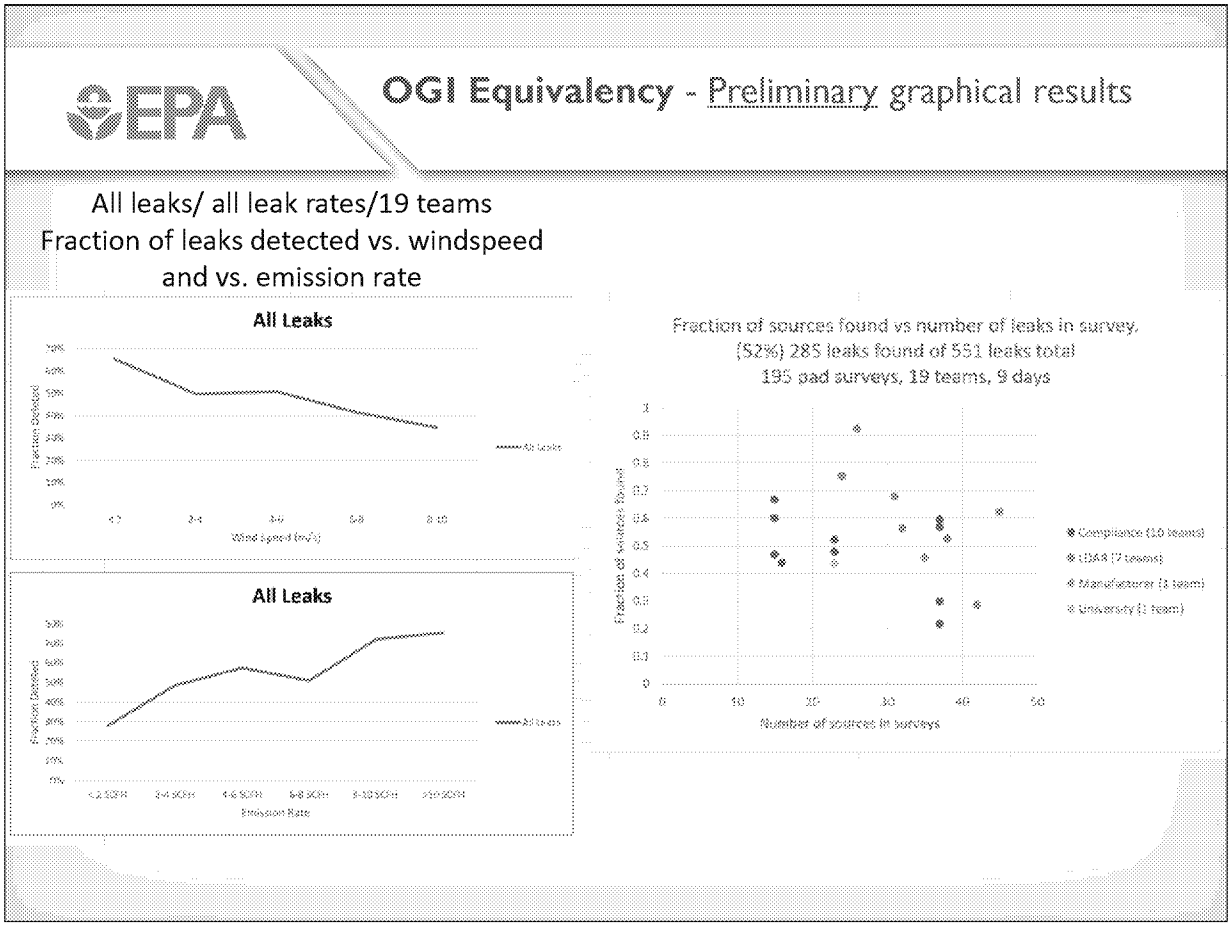
CDPHE – Alex Scherer, Ben Cappa, Tim Taylor, Chris Kester, Craig Giesecke, Elie Schuchardt

WDEQ - Cindi Etchevery, Shayla Schell, Travis Guthrie, Jared Beck … and Miles Buckingham to participate in Sep.



DOE's ARPA-E's Methane Observation Networks with Innovative Technology to Obtain Reductions (MONITOR)

The MONITOR Field Test Site will develop a representative test facility that simulates real-world natural gas operations--at the wellpad and further downstream. Specifically, the MONITOR Test Site supports the operation of a multi-user field test site for MONITOR performers to validate performance under realistic use-case scenarios--and meet the MONITOR program's required metrics related to localization, quantification, communications and cost. Data generated during the field tests will demonstrate the performance capabilities of the technologies and could be used by the MONITOR performers to accelerate the commercialization and/or regulatory approval of their technologies.



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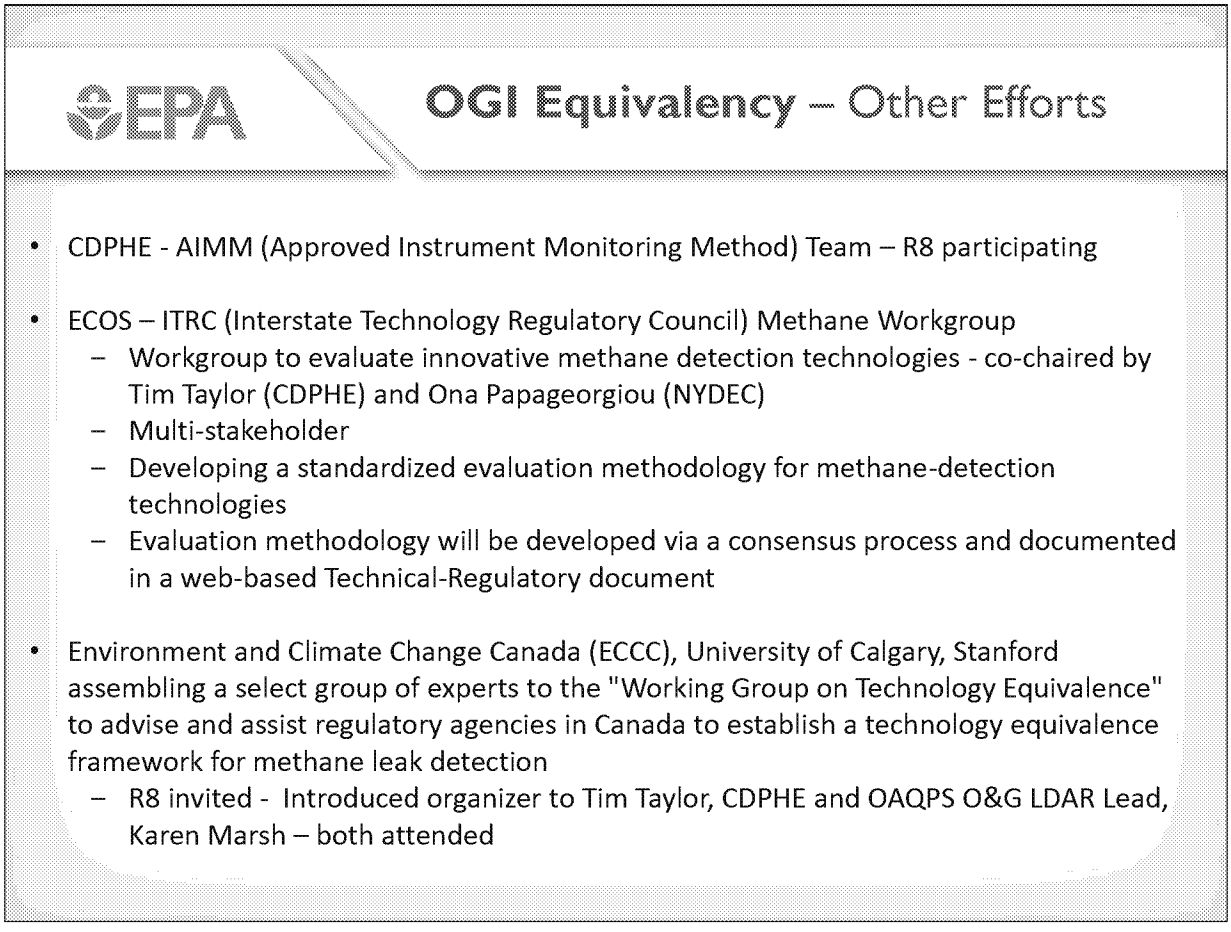


CO
As mentioned above the Colorado regulation includes a provision for an approved instrument monitoring method (AIMM) that is beyond method 21 or OGI. There is currently one alternative method (a hyperspectral imaging system) approved as of October 2016.

WY
The Wyoming Chapter 8 Section 6 rule appears to say that for fugitive LDAR requirements, three quarters of AVO only inspections are sufficient, and one quarter must use instrument based inspection techniques (e.g. flir camera, method 21). However, the actual requirement we've deemed as the baseline is that all inspections must use some instrument based technique.
The rule also requires that companies submit their LDAR protocols for the "fugitive LDAR requirement" under Chapter 8 Section 6(g) to us for approval.
So with regard to alternative methods, yes, they are allowed after review and approval.
Per email 4/5/17 with Jeff Wendt, P.E., District Engineer, Wyoming Department of Environmental Quality, Air Quality Division, 510 Meadowview Drive, Lander, WY 82520.

BLM
The BLM may approve an alternative monitoring device and associated inspection protocol, if the BLM finds that the alternative would achieve equal or greater reduction of gas lost through leaks compared with OGI semiannual/quarterly. The BLM will provide public notice of a submission for approval; the BLM may approve an alternative device and monitoring protocol for use in all or most applications (i.e. once approved, any operator could use it), or for use on a pilot or demonstration basis under specified circumstances that limit where and for how long the device may be used; the BLM will post on the BLM Web site a list of each approved alternative monitoring device and protocol, along with any limitations on its use. The BLM intends that the decision to approve the use of an alternative monitoring device would be made only at the national level, by the Director, Deputy Director, or an Assistant Director, as, once approved, the alternative monitoring device could be used anywhere in the country.

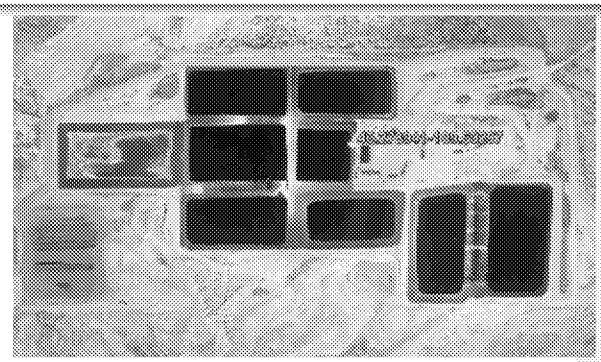
Alternative instrument-based programs - The BLM may approve an operator's request to use an alternative instrument-based leak detection program, (e.g. an operator might propose a program that included more frequent inspections for some sites and less frequent for others, or an operator may be able to deploy an alternative leak detection device or system, approved by the BLM, on a continuous basis and achieve results that would allow for less frequent inspections using optical gas imaging), in lieu of compliance with the semiannual/quarterly requirements, if the BLM finds that the alternative program would achieve equal or greater reduction of gas lost through leaks compared with OGI semiannual/quarterly. The operator must submit its request for an alternative leak detection program through a Sundry Notice that includes the following information:

- (1) A detailed description of the alternative leak detection program, including how it will use one or more of OGI or M21 with AVO, and an identification of the specific instruments, methods and/or practices elements of the approach;
- (2) The proposed monitoring protocol;
- (3) Records and data from laboratory and field testing, including, but not limited to, performance testing, to the extent relevant;
- (4) A demonstration that the proposed alternative leak detection program will achieve equal or greater reduction of gas lost through leaks compared to OGI or M21 with AVO, semiannual/quarterly;
- (5) A detailed description of how the operator will track and document its procedures, leaks found, and leaks repaired; and
- (6) Proposed limitations on types of sites or other conditions on deployment of the alternative leak detection program.

A BLM State Director could approve an alternative leak detection program if the BLM finds that the alternative program would achieve equal or greater reduction of gas lost through leaks compared to the leak detection program required under the rule. The rule does not allow other operators to use an alternative leak detection program requested by and approved for a specific operator, as the results may not be transferable. If the operator demonstrates, and the BLM agrees, that compliance would impose such costs as to cause the operator to cease production and abandon significant recoverable oil or gas reserves under the lease, the BLM may approve an alternative leak detection program (the operator must consider the costs and revenues of the combined stream of revenues from both the gas and oil components and provide the operator's projections of oil and gas prices, production volumes, quality (i.e., heating value and H2S content), revenues derived from production, and royalty payments on production over the next 15 years or the life of the operator's lease

OWDFs – Oilfield Wastewater Disposal Facilities

- UDAQ/UDOGM identified ~25 OWDFs in the Uinta Basin – 18 are on Indian country
- UDAQ - VOC estimates ~23,000 TPY VOCs on Indian country from OWDFs
- Region 8 planning inlet water sampling in October and lab analysis ($10k from OECA) for site-specific air emission estimates



- Formed ad hoc OWDF Air group of air permitting staff (UT, WY, CO and other states outside of R8 like NM, OK, TX) to learn from one another on how to estimate and address air emissions from OWDFs, learn about treatment options from vendors, etc.
  - Shout-outs to Cara Keslar (WY), Todd Wetzel (UT) and Andy Gruel (CO)

Cara Keslar and WDEQ underway with sophisticated analysis to calibrate EPA Water9 air estimating program to work for upstream oil & gas wastewater.